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CONTAMINATION OF VEGETATION AND SOIL BY LEAD AND OTHER ELEMENTS IN THE VICINITY OF THE TONOLLI COMPANY OF CANADA LTD. AND EXIDE CANADA INC., DIXIE ROAD, MISSISSAUGA 1983, 1984, 1985

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Ontario Ministry of the Environment

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Air Resources Branch

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INTRODUCTION

The Phytotoxicology Section has surveyed lead contamination of vegetation and/or soil near the Tonolli Company of Canada and Exide Canada, Dixie Road, Mississauga, annually since 1970. Results of tree foliage sampling conducted in 1982 and earlier years have revealed elevated levels of lead, arsenic, cadmium and antimony relative to the Gerrard Street Control Area in Toronto. However, average foliar levels of these contaminants near Tonolli and Exide in 1982 were considered to be the lowest measured since monitoring of tree foliage began in 1970.

METHODS

In September of 1983, 1984 and 1985, tree foliage samples were collected from 41 stations in the vicinity of Tonolli and Exide (Figure 1), from the sides of trees facing the suspected main source. Control samples of Norway maple and Ailanthus foliage also were collected in September of each year from 10 stations (total 20 samples) in the Gerrard Street Control Area in downtown Toronto (Figure 2).

In addition to vegetation sampling, soil sampling at each station was conducted in 1983 and 1985. Surface soil scrapings (0-1 cm depth) were collected in 1983 in order to estimate the degree of foliar contamination due to soil re-entrainment. Soil samples of 0-5 cm depth were collected in 1985 in order to determine whether a build-up of soil contaminants had occurred since 1980, the year 0-5 cm soil sampling had last been conducted.

Distance and direction of sampling stations from Tonolli or Exide were measured with reference to points located on the respective company properties in the approximate centres of the main emission sources. These points are indicated by stars in Figure 1.

Vegetation and soil samples were processed in the Phytotoxicology laboratory, and were analyzed for lead (Pb), antimony (Sb), arsenic (As) and cadmium (Cd), all of which are potential emissions from Tonolli and Exide, by the MOE Laboratory Services Branch. Additionally, samples collected in 1983 were analyzed for titanium (Ti), which was used as a tracer to estimate soil re-entrainment of lead.

RESULTS

Tree Foliage Results

Lead

Lead concentrations in unwashed tree foliage samples collected in September of 1983, 1984 and 1985 are shown in Table 1, and are compared with prior years' results. Whereas the 1982 levels were considered to be the lowest, on average, of any year since Phytotoxicology surveys were initiated, a trend toward increasing contamination is evident for the 1983, 1984 and 1985 results. The average lead concentration for all stations was higher in 1985 (179 ug/g) than in any previous year since 1979. The percentage of sampling stations having above normal lead concentrations in tree foliage ($>$ 60 ug/g) also increased from 1982 to 1985, after having fallen from 1979 to 1982 (Table 1).

These results indicate that lead emissions from Tonolli/Exide may have been greater in 1985 than during any previous year since 1979.

Effect of Rainfall

Washing of tree foliage samples collected near Tonolli/Exide in September of 1980, using a solution of 0.05% Alconox (soap) and EDTA (metal complexing agent) reduced foliar lead levels by an average of 35% (range 8-65%) compared with unwashed samples. Amount and timing of rainfall also might reduce lead

concentration results for samples analyzed "unwashed" in the lab, although the amount of such reduction might not be expected to be as large as that obtained by the relatively rigorous laboratory washing procedure. However, in order to ensure that inter-year comparisons of unwashed foliar lead results are valid, rainfall statistics should be examined. The figures in Table 2 show variation in rainfall, as measured at Pearson Airport, for the period 1977 to 1985. Total rainfall for the 2-week period and the 5-day period preceding the Tonolli/Exide sample collection dates are shown. The correlation coefficient between the 2-week rainfall and average foliar lead concentration was -0.60, while that between 5-day rainfall and foliar lead was -0.43. Although not significant at the 5% level, these correlations do indicate that rainfall prior to sample collection may reduce foliar lead concentrations, as expected. More importantly, they indicate that the decrease in average foliar lead levels from 1979 to 1982 and subsequent increase through 1985 may have been mainly the result of rainfall variation. In fact, based on this information, it cannot be stated that actual lead emissons from Tonolli/Exide have changed significantly since 1977.

Arsenic, Cadmium, Antimony

Arsenic, cadmium and antimony results for tree foliage collected near Tonolli/Exide in 1983, 1984 and 1985 are summarized in Table 3. Concentrations of all three elements considerably exceeded those in the Toronto control area, with the significance of the differences being antimony > arsenic > cadmium. As for lead, variations from 1983 to 1985 may be ascribed to precipitation differences rather than to changing emissions from the sources.

Relative Contributions of Tonolli and Exide to Foliar Contamination in Their Vicinity

Table 4 compares metal levels in Austrian pine foliage collected from opposite sides of two trees located between Tonolli and Exide. In 1985, concentrations of all elements at both locations were higher in foliage facing Tonolli than in foliage facing Exide. The contour map of lead concentrations in foliage in 1985 (Figure 3) also clearly illustrates that Tonolli was the major of the two sources.

Soil Results

Lead

Concentrations of lead in surface soil (0-5 cm depth) collected in 1985 in the vicinity of Tonolli and Exide are given in Table 5, and are compared with 1980

concentrations. (The 1983 results shown are for 0-1 cm depth and therefore direct comparisons cannot be made.) There is considerable variation inherent in soil sampling results, because metal levels in soils are seldom homogeneous even at a particular sampling station, especially in the vicinity of point sources. This variation, combined with possible site disturbances such as grading, resodding, etc., makes it risky to draw conclusions based on comparisons of single-site results for different years. However, it is possible to obtain a more valid indication of year-to-year changes in soil metal levels by comparing means for several stations. The data in Table 5 show that the average soil lead concentration for the 41 Tonolli/Exide sampling stations increased by 14% from 1980 to 1985. The largest increase, on a concentration basis, occurred at Stations 17 and 19, located immediately east (downwind) of Tonolli. The increases in soil lead concentrations in the immediate vicinity of Tonolli are reflected in the computer-generated isopleths shown in Figure 4.

Arsenic, Cadmium, Antimony

Mean soil levels of other contaminants near Tonolli/Exide also increased from 1980 to 1985 (Table 6). The average increases were 8% for arsenic, 43% for cadmium and 60% for antimony. The increases for cadmium and antimony mainly occurred at stations located in close proximity to Tonolli.

Estimating Re-entrainment Component of Foliar Lead Levels

As part of the 1983 sampling program, soil samples were collected from 0-1 cm depth in the vicinity of the regular foliar sampling stations near Tonolli and Exide. Samples of soil and unwashed foliage were analyzed for titanium in addition to the regularly monitored contaminants. Titanium is ubiquitous in soils at fairly uniform concentrations and is not a component of emissions from secondary lead smelters. Also, it is not an essential element in plant nutrition and is not taken up by plants from soil. Therefore, the presence of titanium on unwashed tree foliage may be ascribed to soil re-entrainment. By comparing ratios of titanium and lead in both unwashed foliage and surface soil (0-1 cm depth), an estimate of lead in foliage due to soil re-entrainment may be obtained.

The results of this procedure are shown in Table 7. Re-entrained lead averaged 10% of total lead in foliage collected from 40 regular sampling stations near Tonolli/Exide in 1983. This estimate is essentially identical to one previously obtained in 1980. However, the 1980 estimate utilized 0-5 cm soil results and aluminum as a tracer (possible uptake by plants from soil) and is regarded as less reliable.

SUMMARY

Concentrations of lead, arsenic, cadmium and antimony in unwashed tree foliage collected in the vicinity of Tonolli and Exide, Mississauga in 1983, 1984 and 1985 were elevated with respect to the Gerrard Street Control Area in downtown Toronto. Concentration distributions implicated Tonolli as the major source.

Decreases in concentrations of lead and other contaminants in unwashed tree foliage collected near Tonolli and Exide had been measured from 1979 to 1982, with subsequent increases through 1985. An examination of rainfall patterns over this period showed that much of the variability in foliar contaminant levels could be ascribed to rainfall, with the lower concentrations being generally associated with higher rainfall amounts in the two-week period preceding sample collection. Therefore, the tree foliage results do not preclude the possibility that little change in contaminant emissions from Tonolli/Exide has occurred since 1979.

Average concentrations of lead in surface soil near Tonolli and Exide increased by 14% from 1980 to 1985. Increases in soil cadmium, arsenic and antimony levels also occurred during this period, with most of the increase occurring in soil immediately east (downwind) of Tonolli.

A 1980 estimate of 10% of foliar lead in the vicinity of Tonolli/Exide attributable to soil re-entrainment was confirmed in 1983 by a more precise technique which utilized titanium as a tracer.

PH78/13

TABLE 1

Lead concentrations (ug/g, dry wt.) in unwashed foliage samples collected in 1977 and 1979 through 1985 in the vicinity of Tonolli and Exide, Mississauga

Station No.	Distance (m) and Direction from Reference Point	Species (1985)	Lead Concentration July 1977	Sept. 1979	Sept. 1980	Sept. 1981	Sept. 1982	Sept. 1983	Sept. 1984	Sept. 1985
1	80 NW of Tonolli	Silver maple	490	710	540	990	572	850	925	900
3	300 NW of Tonolli	Silver maple	171	292	226	294	109	170	300	270
4	480 NW of Tonolli	Silver maple	58	132	96	58	43	62	110	71
9	470 N of Tonolli	Sumach	81	94	63	56	42	-	125	77
12	200 NE of Tonolli	Basswood	610	598	252	266	131	490	825	625
14	500 NE of Tonolli	Apple	143	272	94	43	57	57	155	139
15	780 NE of Tonolli	Man. maple	30	135	44	28	28	57	48	79
17	220 E of Tonolli	Austrian pine	276	262	252	204	172	240	325	405
18	290 E of Tonolli	Silver maple	326	535	404	440	107	360	595	845
19	150 SE of Tonolli	Austrian pine	707	320	605	720	703	260	320	1130
25	240 S of Tonolli	Ash	438	340	353	760	167	440	435	400
26	310 S of Tonolli	Silver maple	-	232	117	294	120	260	150	425
27	490 S of Tonolli	Apple	94	47	88	284	120	97	110	150
28	820 S of Tonolli	Apple	23	91	58	31	34	33	30	76
29	1080 S of Tonolli	Silver maple	-	-	27	18	26	20	12	32
30	230 SW of Tonolli	Ash	79	111	73	121	91	75	68	94
31	460 SW of Tonolli	Apple	-	55	50	52	42	27	30	70
36	350 W of Tonolli	Man. Maple	73	110	63	70	42	30	26	61
38	790 W of Tonolli	Elm	26	69	39	45	22	39	28	35
42	850 NW of Exide	Black walnut	62	99	64	49	43	42	64	88
45	260 N of Exide	Cherry	191	436	140	108	85	90	100	210
49	80 NE of Exide	Honey locust	-	-	322	314	214	130	110	90
50	310 NE of Exide	Norway maple	-	148	30	45	30	47	54	61
51	460 NE of Exide	Elm	21	144	56	56	47	72	91	102
52	700 ENE of Exide	Norway maple	24	46	14	18	17	14	16	26
54	180 E of Exide	Norway maple	189	103	49	49	31	37	60	66
55	490 E of Exide	Austrian pine	63	36	30	26	17	32	24	26
56	690 ESE of Exide	Norway maple	44	-	24	21	14	14	20	26
57	840 E of Exide	Sugar maple	49	21	9	7	10	8	17	8
58	90 SE of Exide	Silver maple	191	430	192	325	142	300	395	116
59	200 SE of Exide	Norway maple	133	148	67	67	35	29	80	63
60	310 SE of Exide	Silver maple	136	115	66	97	66	47	80	68
61	460 SE of Exide	Norway maple	36	74	31	31	18	15	24	22
62	630 SE of Exide	Norway maple	97	57	34	40	-	33	29	34
64	220 S of Exide	Norway maple	104	155	52	58	33	36	66	70
65	360 S of Exide	Sugar maple	90	105	51	71	38	49	57	48
66	575 SSW of Exide	Ash	77	50	26	31	16	15	27	33
67	810 S of Exide	Norway maple	57	51	26	40	19	13	20	27
68	150 SW of Exide	Ash	122	312	126	81	91	68	97	190
71	790 SW of Exide	Apple	52	120	50	54	22	29	37	74
72	1150 SW of Exide	Manitoba maple	-	-	17	31	13	11	11	24
Tonolli/Exide - Mean:			154	191	120	156	91	118	149	179
Tonolli/Exide - Minimum:			21	21	9	7	10	8	11	9
Tonolli/Exide - Maximum:			707	710	605	990	703	850	925	1130
Control Area - Mean:			40	44	18	19	14.5	18.2	16.5	21.7
% of stations exceeding current "upper normal" level* (underlined):			71	78	51	44	38	40	54	71

* Note - Phytotoxicology Section "upper limit of normal" lead level in unwashed urban tree foliage is 60 ug/g.

Table 2

Rainfall Statistics (Pearson Airport)

Year	Vegetation Collection Dates (Tonolli/Exide)	Rainfall in 2 week period prior to sample collection (mm)	Rainfall in 5 day period prior to sample collection (mm)	Average lead concentration (ug/g, dry wt.) in unwashed Tonolli/Exide tree foliage samples
1977	July 29	17.2	16.2	154
1979	Sept. 25, 26	40.1	0	191
1980	Sept. 29, 30	29.0	0.7	120
1981	Sept. 24	20.4	15.8	156
1982	Sept. 22, 23	88.7	16.7	91
1983	Sept. 15, 19	37.9	36.7	118
1984	Sept. 10, 11	64.5	27.1	149
1985	Sept. 20, 23, 24	5.3	5.3	179

Table 3

Summary of arsenic, cadmium and antimony levels (ug/g, dry weight) in unwashed tree foliage near Tonolli and Exide - 1983, 1984, 1985

Statistical parameter	Arsenic	Cadmium	Antimony
1983 - mean	0.76	0.32	2.8
- minimum	0.03	< 0.1	0.12
- maximum	4.8	2.8	28
- % of stations with "above-normal" concentrations	7.5	0	68
- control area mean	0.12	< 0.1	0.11
1984 - mean	0.74	0.44	3.8
- minimum	< 0.03	< 0.1	0.06
- maximum	4.6	2.8	40
- % of stations with "above-normal" concentrations	4.9	0	78
- control area mean	0.19	< 0.1	0.07
1985 - mean	0.92	0.40	3.6
- minimum	0.12	< 0.1	0.20
- maximum	4.0	2.8	27
- % of stations with "above-normal" concentrations	7.3	0	85
- control area mean	0.21	< 0.1	0.21
Phytotoxicology Section "upper limits of normal" concentrations in unwashed urban tree foliage	2	3*	0.5

* under review

Table 4

Contaminant concentrations (ug/g, dry weight) in unwashed current year needles collected from opposite sides of Austrian pine located between Tonolli and Exide, Mississauga - 1977, 1983, 1984, 1985

Station and Side Sampled	Lead				Arsenic				Cadmium				Antimony			
	1977	1983	1984	1985	1977	1983	1984	1985	1977	1983	1984	1985	1977	1983	1984	1985
Station 19 - facing Tonolli	707	280	320	1130	10.9	0.95	2.0	3.6	1.3	0.8	1.0	0.8	-	5.1	16.9	17.8
Station 19 - facing Exide	214	243	200	675	3.2	0.45	0.70	1.6	1.0	0.6	0.4	0.6	-	2.1	2.7	8.1
Station 17 - facing Tonolli	276	243	325	405	7.4	0.48	0.80	1.3	0.8	0.6	0.2	0.6	-	2.2	6.2	6.5
Station 17 - facing Exide	111	167	125	215	1.9	0.37	0.34	0.54	0.6	0.4	0.2	0.4	0	1.5	1.7	1.6

Station Locations

Station 19 - 160m SE of Tonolli and 370m W of Exide

Station 17 - 220m E of Tonolli and 260m W of Exide

TABLE 5

Lead concentrations (ug/g, dry wt.) in surface soil samples collected 1980, 1983, 1985, in the vicinity of Tonolli and Exide, Mississauga

Station No.	Distance (m) and Direction from Reference Point	Lead Concentration 1980 (0-5 cm)	1983 (0-1 cm)	1985 (0-5 cm)	% change 1980-1985
1	80 NW of Tonolli	1280	350	1900	48
3	300 NW of Tonolli	180	1120	135	-25
4	480 NW of Tonolli	60	260	68	13
9	470 N of Tonolli	40	-	36	-10
12	200 NE of Tonolli	2230	6130	4700	111
14	500 NE of Tonolli	335	790	460	37
15	780 NE of Tonolli	135	71	175	30
17	220 E of Tonolli	1250	23,000	7075	466
18	290 E of Tonolli	1860	3400	1950	5
19	150 SE of Tonolli	9750	10,300	15,750	62
25	240 S of Tonolli	785	1730	545	-31
26	310 S of Tonolli	390	780	745	91
27	490 S of Tonolli	105	1930	255	143
28*	820 S of Tonolli	175	2670	205	17
29*	1080 S of Tonolli	140	610	53	-62
30	230 SW of Tonolli	5730	880	5400	-6
31	460 SW of Tonolli	200	97	230	15
36	350 W of Tonolli	575	150	340	-41
38	790 W of Tonolli	190	1530	225	18
42	850 NW of Exide	140	200	250	79
45	260 N of Exide	525	1500	310	-41
49	80 NE of Exide	5180	1870	680	-87
50	310 NE of Exide	245	220	220	-10
51	460 NE of Exide	1230	1900	1500	22
52*	700 ENE of Exide	85	410	108	27

(cont'd....)

TABLE 5 (cont'd)

Lead concentrations (ug/g, dry wt.) in surface soil samples collected 1980, 1983, 1985, in the vicinity of Tonolli and Exide, Mississauga

Station No.	Distance (m) and Direction from Reference Point	Lead Concentration 1980 (0-5 cm)	1983 (0-1 cm)	1985 (0-5 cm)	% change 1980-1985
54*	180 E of Exide	<u>965</u>	1200	<u>940</u>	-3
55*	490 E of Exide	375	400	345	-8
56*	690 ESE of Exide	285	140	66	-77
57*	840 E of Exide	225	1300	175	-22
58*	90 SE of Exide	<u>5130</u>	3300	<u>1800</u>	-65
59*	200 SE of Exide	<u>975</u>	1270	<u>1025</u>	5
60*	310 SE of Exide	495	1570	445	-10
61*	460 SE of Exide	275	350	53	-81
62*	630 SE of Exide	475	2200	<u>740</u>	36
64*	220 S of Exide	375	380	300	-20
65*	380 S of Exide	225	350	240	7
66*	575 S of Exide	115	360	125	9
67*	810 S of Exide	100	170	56	-44
68	150 SW of Exide	<u>1030</u>	290	330	-68
71	790 SW of Exide	300	270	400	33
72	1150 SW of Exide	50	320	80	60
Mean soil lead concentration:		1078	1894	1230	14.1
% of stations exceeding current "upper normal" level (underlined):		37	-	34	

<u>Note</u> - Phytotoxicology Section "upper limit of normal" lead concentration in urban soil (0-5 cm depth) is 500 ug/g.

* Sampling station located on residential or public property (residential boulevards, parkland)

Table 6

Summary of arsenic, cadmium and antimony levels (ug/g, dry weight) in surface soil near Tonolli and Exide, Mississauga - 1980, 1983, 1985

Statistical Parameter	Arsenic	Cadmium	Antimony
1980 (0-5 cm depth)			
- mean	18.5	0.7	6.2
- minimum	0.6	< 0.5	0.4
- maximum	70	8.3	43.8
- % of stations with "above-normal" concentrations	34	4.9	24
- control area mean	7.2	1.0	3.9
1983 (0-1 cm depth)			
- mean	9.9	2.0	22.2
- minimum	1.5	0.2	0.33
- maximum	91.2	21.3	452
- control area mean	4.0	1.1	1.6 (35.5)
1985 (0-5 cm depth)			
- mean	20.0	1.0	9.9
- minimum	3.0	< 0.2	0.32
- maximum	94.6	9.4	81.3
- % of stations with "above-normal" concentrations	32	7.3	22
- control area mean	5.9	0.86	2.9
Phytotoxicology Section "upper limits of normal" concentrations in urban surface soil (0-5 cm depth)	20	4	8

Table 7

Estimated contribution from soil re-entrainment to lead content of tree foliage in the vicinity of Tonolli of Canada and Exide Canada Corp., Mississauga - September, 1983.

Sample Group	Statistics	Tree Foliage (unwashed)			Surface Soil (0-1 cm)			Estimated ppm Pb in Foliage due to Re-entrainment (off property)	Re-entrained Pb as % of Total Pb	Enrichment Factor (E.F.)**
		Pb (ppm)	Ti (ppm)	Pb/Ti	Pb (ppm)	Ti (ppm)	Pb/Ti			
"High Pb" Tonolli/ Exide stations (>50 ppm Pb, mean distance 300 m from source(s) (n=18)	Mean	238	13.7	20.8	3310	2660	1.23	15.6	8.1	66.5
	± S.D.*	± 208	± 5.5	± 22.1	± 5520	± 525	± 2.3	± 29.8	± 12.2	± 123
	Minimum	57	5.7	2.4	71	1460	0.021	0.19	0.21	1.8
	Maximum	850	31	86	23000	3460	10	130	54	490
"Low Pb" Tonolli/ Exide stations (<50 ppm Pb, mean distance 600 m from source(s) (n=22)	Mean	28	13.4	2.3	735	3270	0.24	3.1	12.2	19.5
	± S.D.	± 13	± 5.4	± 1.1	± 730	± 800	± 0.24	± 3.4	± 14.2	± 14.9
	Minimum	8	5.9	0.79	87	1580	0.023	0.34	1.9	1.6
	Maximum	49	26	4.5	3670	5120	0.72	14	60	52
All Tonolli/ Exide stations (mean distance 460 m from source(s) (n=40)	Mean	118	14	10	1890	3080	0.70	8.7	10	41
	± S.D.	± 170	± 5.4	± 17	± 3900	± 770	± 1.6	± 21	± 13	± 85
	Minimum	8	5.7	0.79	71	1460	0.021	0.19	0.21	1.6
	Maximum	850	31	86	23000	5120	10	130	60	490
Gerrard Street Control Area, Toronto (n=20)	Mean	18	13	1.5	750	3250	0.23	2.7	17	12
	± S.D.	± 7.8	± 4.0	± 0.89	± 870	± 390	± 0.25	± 2.6	± 13	± 13
	Minimum	7	7.8	0.47	230	2260	0.066	0.59	1.6	1.9
	Maximum	36	21	4.0	3130	3620	0.90	12	55	61

*S.D. = Standard Deviation

**E.F. = $(Pb_{(F)}/Ti_{(F)}) \div (Pb_{(S)}/Ti_{(S)})$

Figure 1 - Locations of sampling stations in the vicinity of Tonolli and Exide, Mississauga.

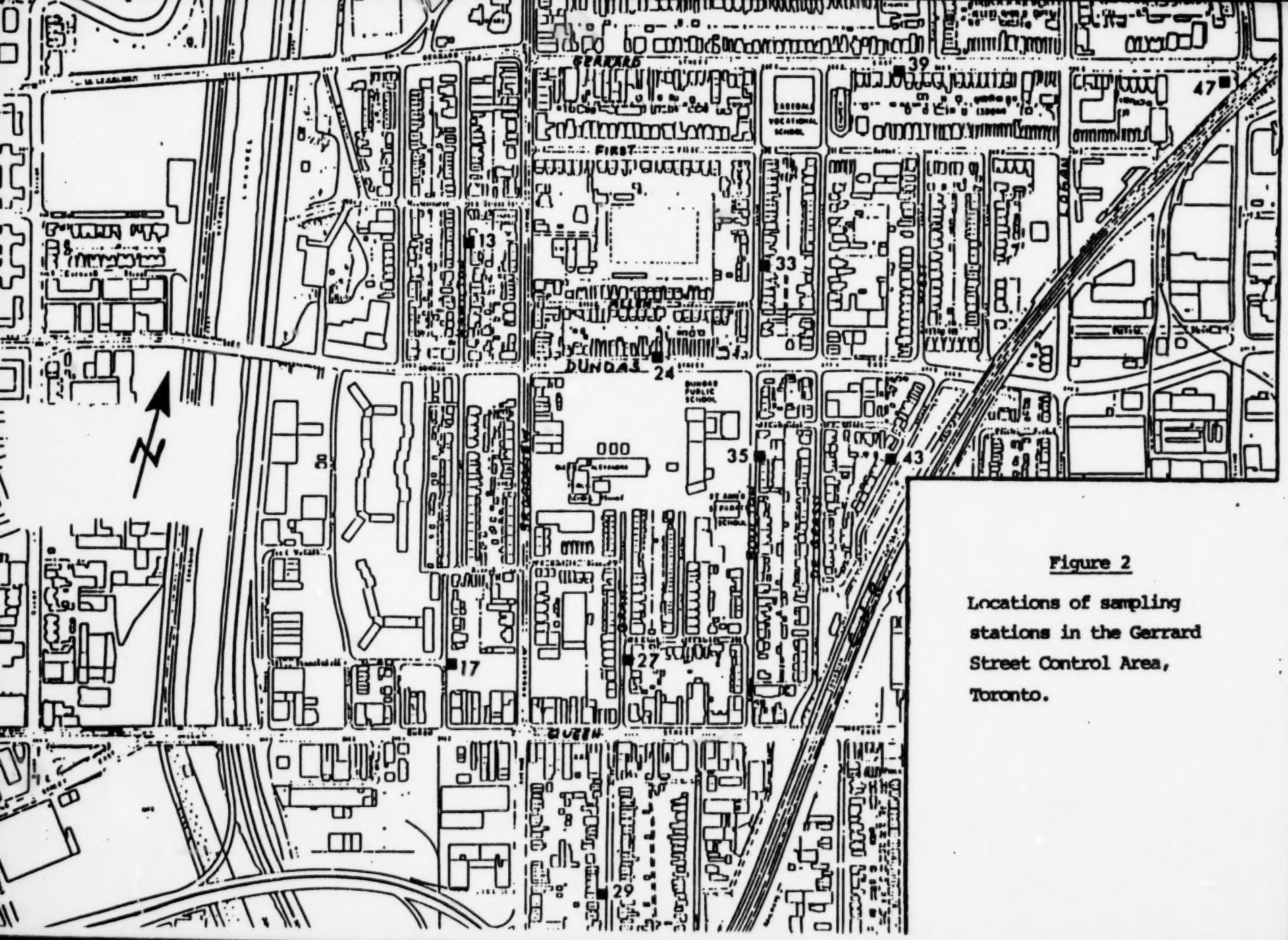
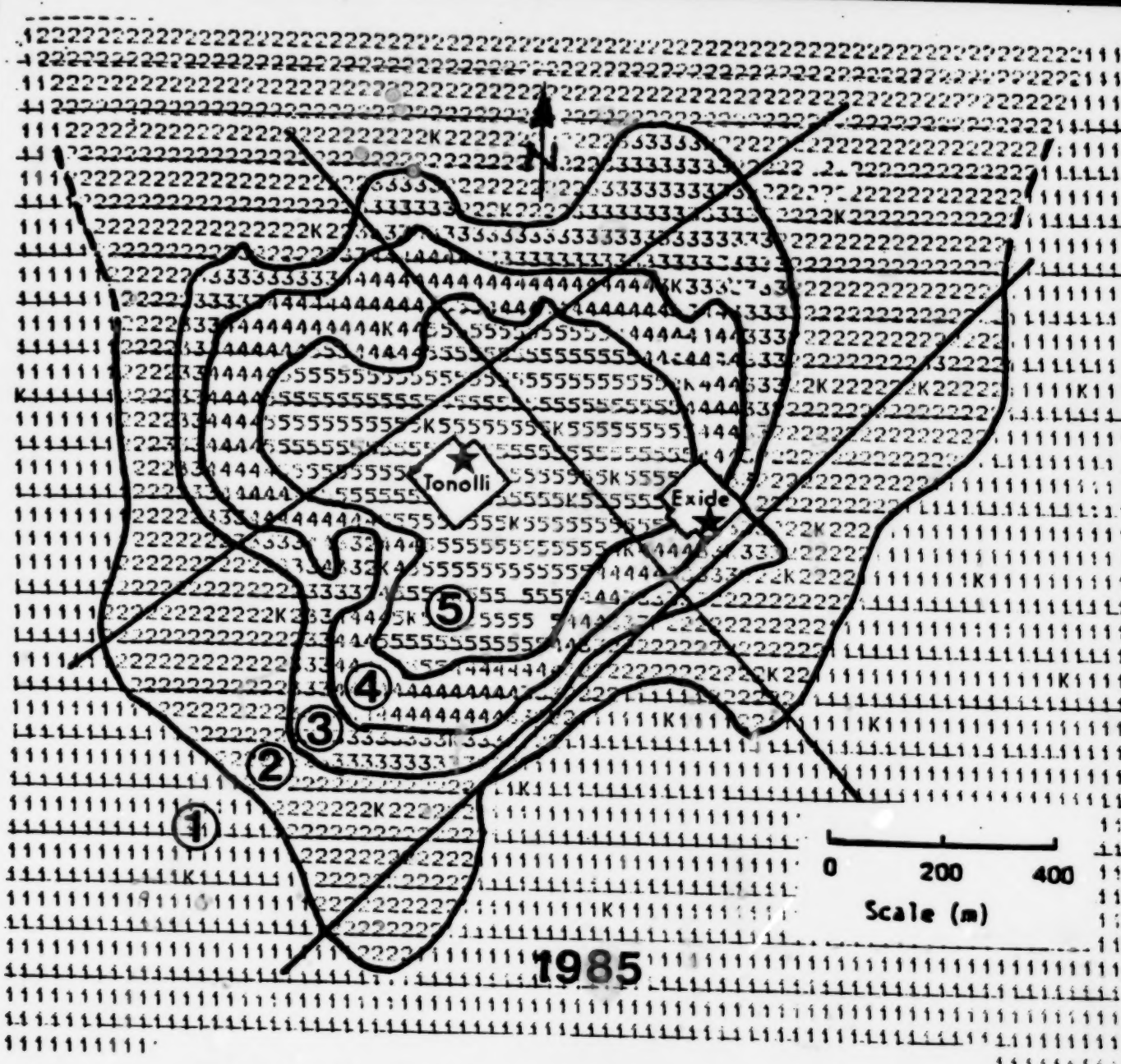


Figure 2

Locations of sampling stations in the Gerrard Street Control Area, Toronto.



Pb (ug/g, dry weight):

①	②	③	④	⑤
0 - 60	61 - 100	101 - 150	151 - 300	> 300

Figure 3 - Contour map of lead concentrations in unwashed tree foliage in the vicinity of Tonolli and Exide, Mississauga - 1985.

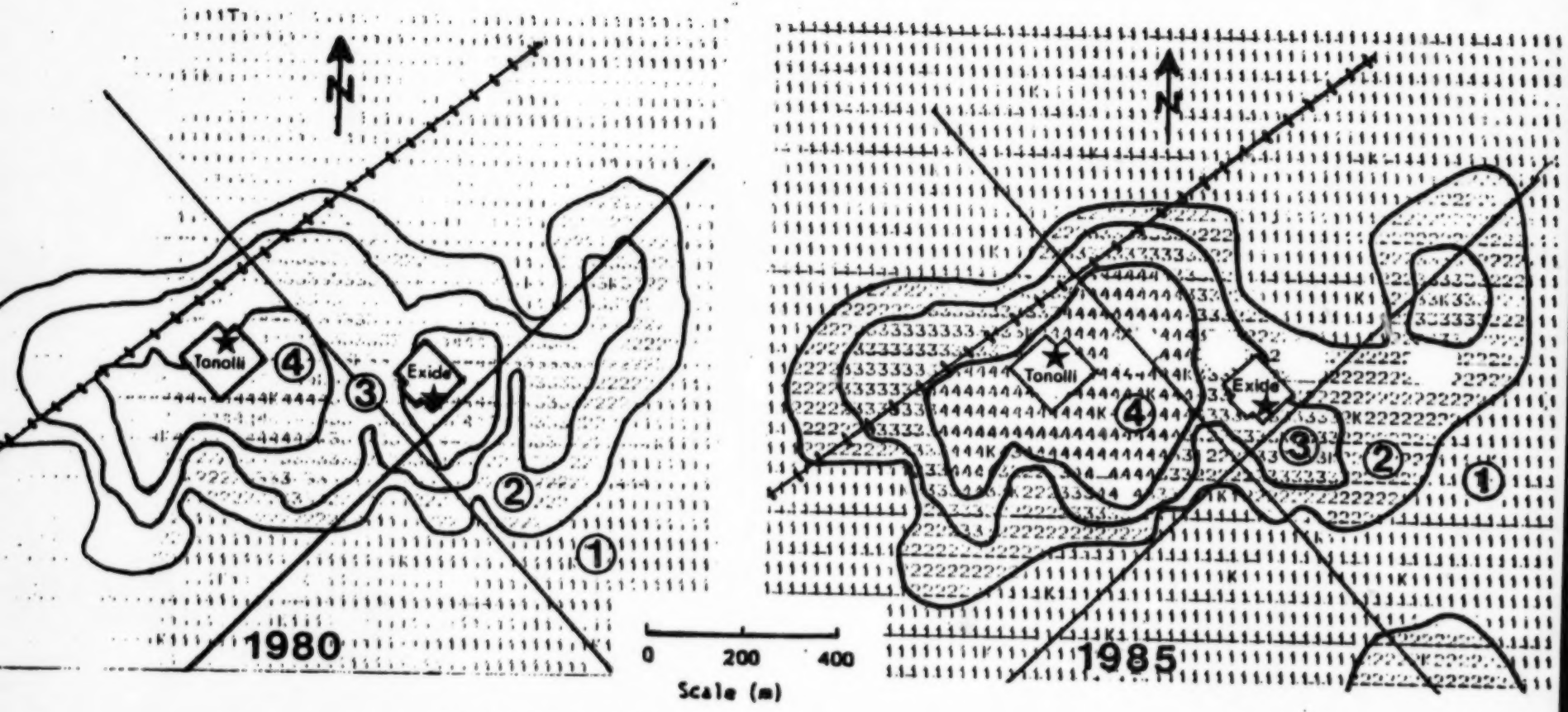


Figure 4 - Contour maps of lead concentrations in surface soil (0 - 5 cm depth) in the vicinity of Tonolli and Exide, Mississauga - 1980, 1985.